GENERAL DYNAMICS | CONVAIR

Report No. 8926-161

Material - Transparency - Plastic - Plexiglas 55

Static and Fatigue Strength

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30 September 1957

Published and Distributed
under
Contract AF33(657)-8926

Post Office Box 1950, San Diego 12, California 296-6611
Material Post Office Box 2071 273-8000 | Accounting Post Office Box 510

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Abstract:

Static tensile and notched tensile, tensile fatigue, crack propagation, edge attachment and shear-out tests were made with biaxially stretched (70% approx.) Plexiglas 55 supplied by the Swedlow Plastics Co., Los Angeles, Calif. The test data resulting from tests at -50, 75 and 195°F are given in tabulations and charts.

Reference: Schiff, E., McNelly, J. P., Wise, W. E., "Plexiglass 55 - Physical Properties - Static and Fatigue Tests," General Dynamics/ Convair Report SL 56-164, San Diego, California, 30 September 1957. (Reference attached).

CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION
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STRUCTURES & MATERIALS LABORATORIES

REPORT 56-164
DATE 30 September 1957
MODEL F-102A

TITLE

REPORT NO. 56-164
PLEXIGLAS 55 - PHYSICAL PROPERTIES
STATIC AND FATIGUE TESTS
MODEL F-102

CONTRACT NO. AF 33(600)-5942

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NO. OF PAGES 25
NO. OF DIAGRAMS 21

REVISIONS

NO.	DATE	BY	CHANGE	PAGES AFFECTED
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FORM 1612A-4

REPORT NO. 56-164
PLEXIGLAS 55 - PHYSICAL PROPERTIES
STATIC AND FATIGUE TESTS
MODEL F-102A

REFERENCES:

(a) Federal Specification LP 406 b, "Plastics, Organic: General Specifications, Test Methods", dated 27 September 1951.

(b) Convair Specification ZM-8-104, "Specification for Canopy and Windshield Materials Development".

OBJECT:

To determine various physical properties of Plexiglas 55, biaxially stretched approximately 70%, for design information purposes and to provide data for the selection of minimum acceptable properties for a procurement specification.

TEST SPECIMENS:

All stretched test specimens were from a single lot of Plexiglas 55 stretched and furnished by Swedlow Plastics Company. After stretching the material, the vendor subjected it to the same heat cycle as a production F-102A canopy panel. Two shrink-back specimens cut from this sheet and shrunk back gave an average stretch percentage of 66.2. As-cast Plexiglas 55 was also furnished by Swedlow Plastics Company.

Specimen configurations were as follows:

Static tensile tests - The 75°F and 194°F specimens were standard tensile coupons in accordance with Reference (a); the -50°F specimens were modified as shown in Figure 1 to cause failure to occur at the center, since they otherwise often failed at the grips.

Static notched tensile tests - These were made as shown in Figures 2 and 3.

Tensile fatigue tests - The specimen shown in Figure 1 was used at 75°F and 194°F; the -50°F specimens were modified as shown in Figure 4, to cause failure at the center.

Crack propagation tests - Standard 2 inch x 6 inch specimens were used, in accordance with Reference (b). See Figure 14.

Edge attachment tests - Convair 8-07142 specimens were made by Swedlow Plastics Company, per Reference (b). See Figure 5.

Shear-out tests - The specimen is shown in Figure 6.

TEST PROCEDURES:

Static tensile tests - Reference (a) was followed, except that the load rate was changed to .02 inch per minute, to more closely approach the estimated load rate in service. Five specimens were run at each of 3 temperatures: 75°F, 194°F and -50°F.

Static notched tensile tests - The same procedure as for unnotched tensile tests was followed. Ten specimens each of stretched and as-cast Plexiglas 55 were tested at 75°F.

Tensile fatigue tests - A Triplett and Barton fatigue machine was used to load the specimens, at a rate of 15 cycles per minute. Four points were obtained on an S-N curve at 194°F. Five specimens were run at 75°F at 7,000 psi for a minimum of 20,000 cycles, and five were run at -50°F at 10,000 psi for a minimum of 20,000 cycles.

Crack propagation tests - Reference (a) was followed, with load rate adjusted to fail the specimen in 3 to 5 minutes. Five specimens were tested at each of 3 temperatures: 75°F, 194°F and -50°F.

Edge attachment tests - A set of holding fixtures simulating the canopy edge attachment were used. This loaded the specimen eccentrically, similar to the way the actual canopy frame loads the plastic panel. Five specimens were tested at each of 3 temperatures: 75°F, 194°F and -50°F.

Shear-out tests - The specimens were loaded in double shear, using a .186 inch diameter pin. All tests were at 75°F. An attempt was made to cause a shear failure, by varying the edge distance.

RESULTS:

Results of all tests are given in Tables I through V, and failed specimens are shown in Figures 8 through 16. The edge attachment specimens all failed initially by shearing the orlon-acrylic impregnate ledge. The 75°F specimens were reloaded after this failure, until complete tensile failure through the Plexiglas occurred.

The shear-out tests were halted after edge distances as low as 1 d failed to produce a shear failure; all specimens failed in tension. Failing loads were as follows:

Specimen	Edge Distance	Ultimate - Lbs.
257C-1	2 d	1520
257A-1	1.5 d	1225
257A-2	1 d	750

An S-N curve of tensile fatigue data at 194°F is given in Figure 7.

NOTE:

The test data from which this report was prepared are recorded in Structures Test Laboratory Data Book No. 4005, pages 5 through 9.

TABLE INDEX

TABLE I

STATIC TENSILE TESTS - STRETCHED PLEXIGLAS 55 - (SWEDLOW PLASTICS COMPANY)

SPECIMEN NO.	TEST TEMP. °F.	TEST SPEED IN./MIN.	SPECIMEN T. IN.	SPECIMEN W. IN.	ULTIMATE LOAD LBS.	ULTIMATE STRESS P.S.I.		REMARKS
257B - 17	76	.02	.357	.751	3180	11900		
257B - 16	75		.357	.750	3200	11950		
459D - 11	75		.359	.745	3130	11720		
459D - 12	75		.361	.745	3135	11650		
459D - 13	75		.356	.745	3195	12060		
					Av.	11856		
459D- 5	194		.352	.745	1220	4660		
459D - 7	194		.354	.746	1100	4170		
459D - 8	194		.355	.745	1120	4240		
459D - 9	194		.357	.744	1180	4440		
459D - 10	194		.358	.745	1140	4270		
					Av.	4356		
459A- 15	-50		.368	.500	3920	21293		
459A - 17	-50		.358	.500	3300	18581		
459A - 18	-50		.355	.498	3410	19266		
459A- 19	-50		.355	.500	3430	19313		
459A - 20	-50	.02	.356	.498	3090	17467		
					Av.	19184		

TABLE II

STATIC NOTCHED TENSILE TESTS - AS-CAST AND STRETCHED PLEXIGLAS 55

MAT'L	SPECIMEN NO.	TEST TEMP. F.	TEST SPEED IN/MIN.	SPECIMEN T. IN.	SPECIMEN W. IN.	ULTIMATE LOAD LBS.	ULTIMATE STRESS P.S.I.
STRETCHED PLEX 55	257A-1	76	.02	.233	.516	600	4990
	2	77		.235	.519	920	7480
	3	77		.237	.517	900	7350
	4	76		.237	.516	960	7850
	5	76		.238	.513	940	7700
	6	75		.238	.523	780	6260
	7	75		.239	.525	1040	8290
	459D-1	75		.228	.509	775	6670
	2	75		.229	.510	1010	8650
STRETCHED PLEX 55	3	76		.230	.508	1075	9200
						Av.	7444
AS-CAST PLEX 55	ACP55-1	75		.330	.509	405	2410
	2	75		.330	.497	370	2260
	3	75		.331	.506	330	1970
	4	74		.330	.510	285	1690
	5	73		.330	.509	170	1010
	6	73		.333	.504	230	1370
	7	74		.338	.508	235	1370
	8	74		.330	.506	215	1290
	9	73		.331	.508	205	1220
AS-CAST PLEX55	10	74	.02	.330	.506	200	1190
						Av.	1578

TABLE III

CRACK PROPAGATION TESTS - STRETCHED PLEXIGLAS 55

Specimen No.		Temp. °F	Load Rate lb/min	T in.	X in.	P lbs.	K lb/in 3/2
257	-1	75	600	.350	.35	2600	2820
	2			.351	.33	2750	2860
	3			.365	.33	2850	2670
	4			.353	.40	2600	2980
	5			.351	.55	2850	3060
						Av.	2878
459C	-6	194		.362	.84	2590	4561
	7			.362	1.00	2370	4951
	8			.363	.83	2650	4617
	9			.368	.62	2840	4013
	10			.371	.64	2780	3981
						Av.	4425
459D	-1	-50	400	.345	.250	1560	1424
	2			.345	.240	1645	1466
	3			.347	.245	1650	1480
	4			.348	.250	1740	1575
	5			.350	.230	1540	1331
						Av.	1455

TABLE IV.

EDGE ATTACHMENT STATIC TENSILE TESTS - STRETCHED PLEXIGLAS 55

Specimen Type	Specimen No.		Test Temp. °F	Load Rate in/min	Primary Ultimate lbs.	Primary Ultimate psi*	Secondary Failure lbs.	Secondary Failure psi
8-07142	SS-1877	-1	75	.02	984	1763	3130	5609
		-2			1180	2115	2710	4857
		-3			1110	1989	2910	5215
		-4			1090	1953	2440	4373
		-5			1070	1918	2800	5018
				Av.	1087	1948	2798	5014
		-6	194		360	651		
		-7			408	738		
		-8			460	832		
		-9			438	792		
		-10			532	962		
				Av.	440	795		
		-11	-50		1312	2457		
		-12			1476	2764		
		-13			1492	2794		
		-15			1508	2824		
		-16			1670	3127		
				Av.	1492	2793		

* Based on net tensile area of plex.
Primary failure was shear failure of adhesive
Secondary failure was tensile failure of plex.

TABLE V

TENSILE FATIGUE TEST RESULTS - STRETCHED PLEXIGLAS 55

SPECIMEN NO.	TEMP. °F	WIDTH IN.	THICKNESS IN.	LOAD LBS.	STRESS PSI	FAILURE CYCLES	REMARKS
257 D 30	194	.504	.355	716	3915	182	
29		.501	.354	701	4088	288	Av. 415
28		.500	.354	701	3976	406	
C 25		.494	.356	701	3987	784	
24		.498	.356	621	3499	1796	
26		.501	.357	621	3475	414	Av. 918
29		.496	.356	621	3513	544	
30		.500	.356	619	3438	863	
27		.498	.357	601	3383	2203	Av. 1511
23		.504	.357	611	3402	1469	
28		.501	.357	604	3380	18361	No Failure
21		.499	.357	533	2996	16807	No Failure
19		.502	.357	536	2992	9931	
22		.496	.357	529	2996	624	Av. 4499
17		.498	.359	534	2988	2943	
20		.500	.357	535	3000	55510	No Failure
18		.499	.358	535	2995	16372	No Failure
B 2	75	.500	.356	1246	7001	22017	"
10		.500	.357	1250	7003	24961	"
5		.501	.353	1240	7003	36584	"
8		.501	.357	1250	6992	22835	"
7		.505	.354	1250	6992	22301	"
13	-50	.350	.358	1254	9997	21001	"
14		.348	.358	1250	10036	21115	"
11		.350	.357	1250	10000	24312	"
15		.349	.357	1246	9994	23734	"
9		.351	.357	1252	10005	20494	"

FIGURE INDEX

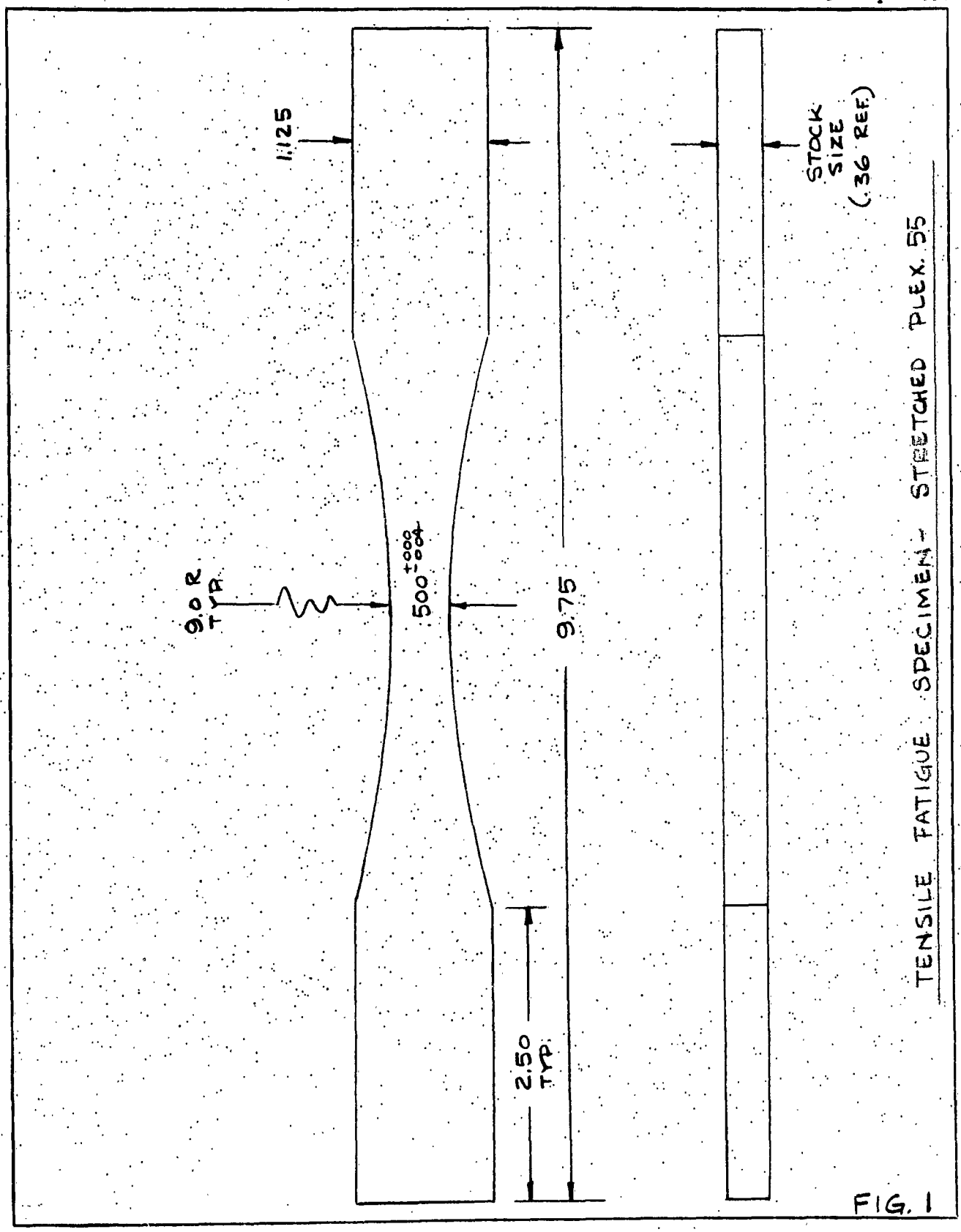

1.125
STOCK SIZE (.36 REF.)
9.0 R TYP
.500 +.000 -.004
9.75
2.50 TYP
TENSILE FATIGUE SPECIMEN - STRETCHED PLEX. 55

FIG. 1

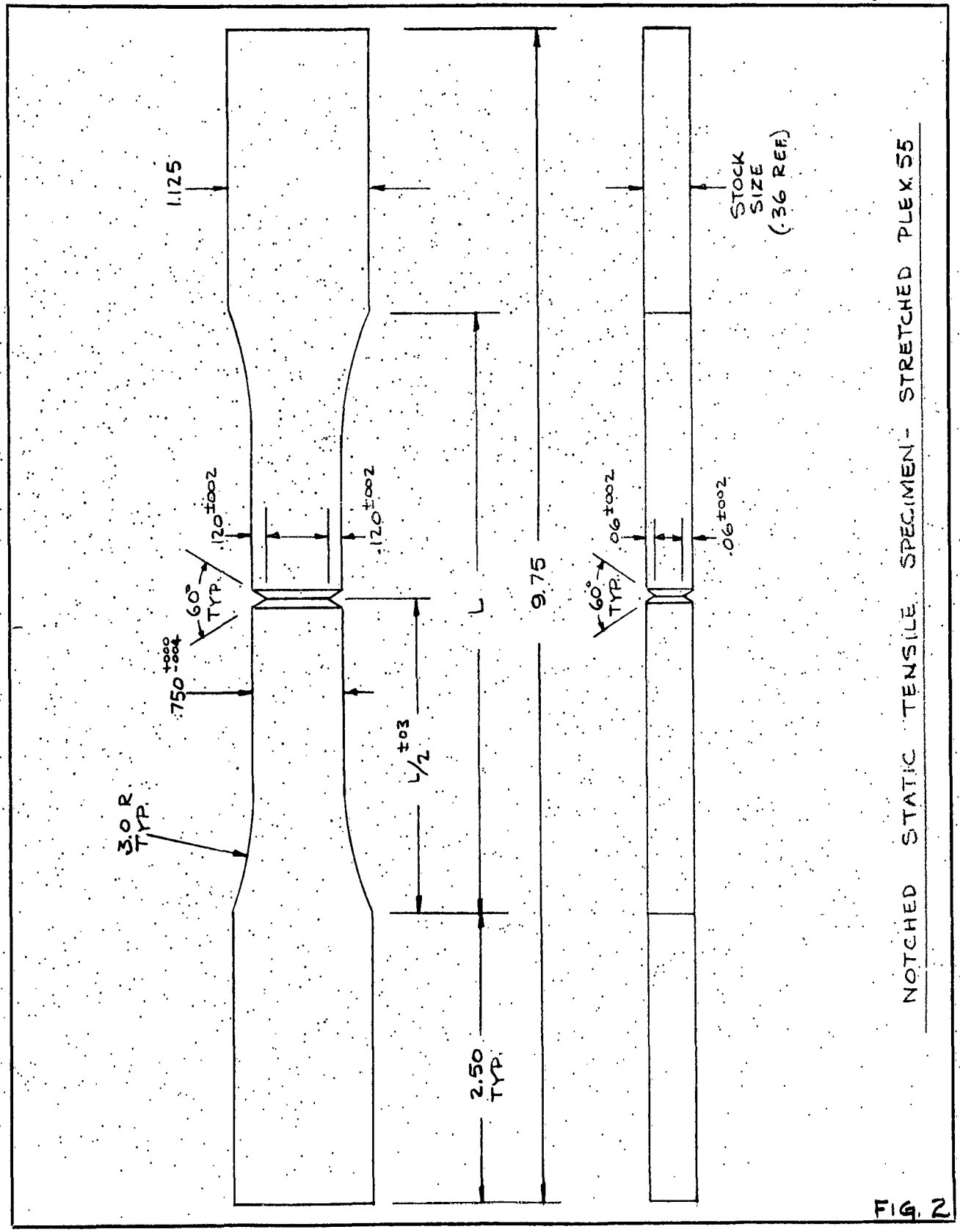

1.125
.120±.002
.120±.002
60° TYP.
.750 +.000 -.004
3.0 R TYP.
L/2 ±.03
L
9.75
2.50 TYP.
.06±.002
.06±.002
60° TYP.
STOCK SIZE (.36 REF.)
NOTCHED STATIC TENSILE SPECIMEN - STRETCHED PLEX.55

FIG. 2

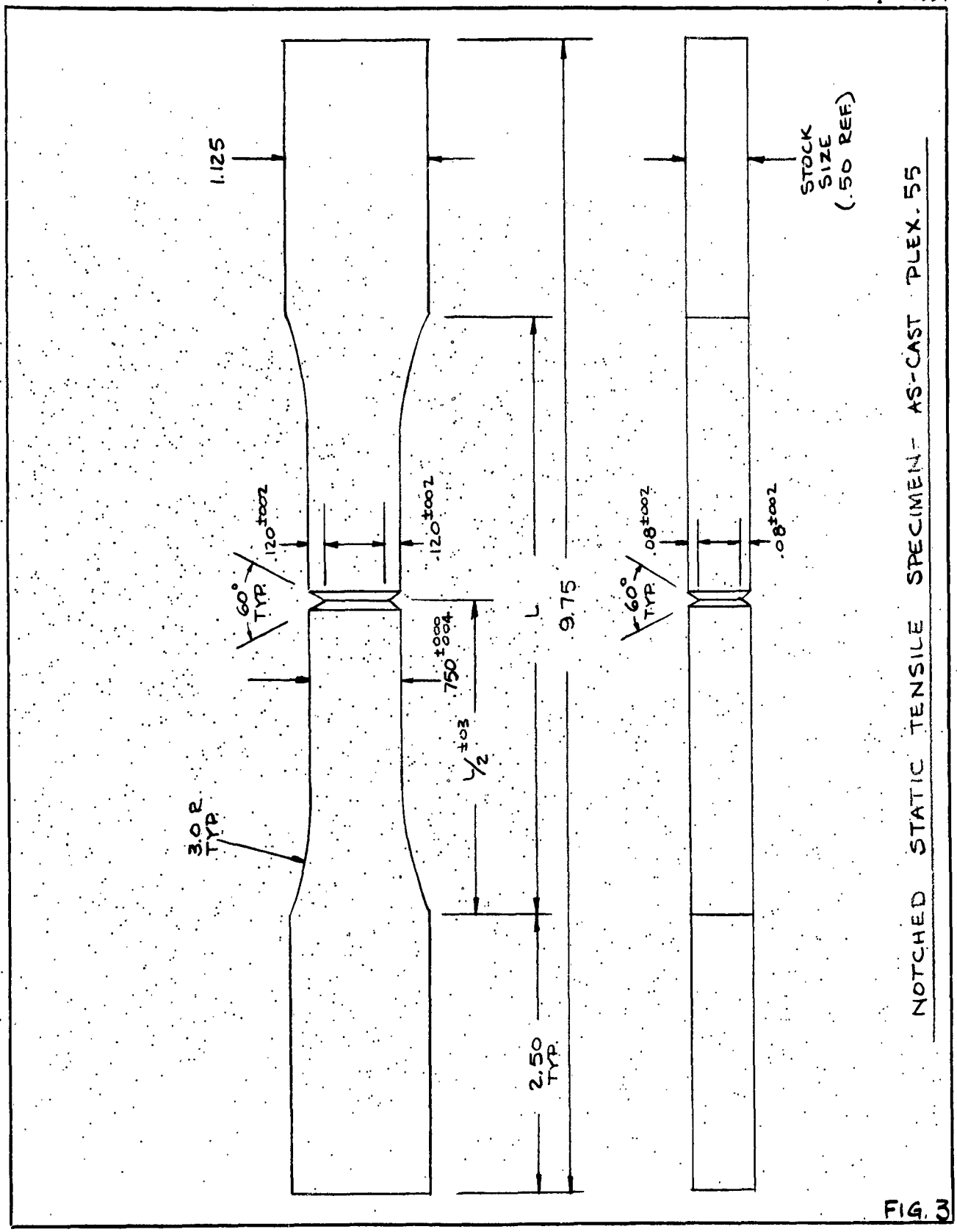

1.125
.120±002
60° TYP.
.120±002
.750±004
L/2±03
3.0 R TYP.
L
9.75
2.50 TYP.
STOCK SIZE (.50 REF.)
.08±002
60° TYP.
.08±002
NOTCHED STATIC TENSILE SPECIMEN- AS-CAST PLEX. 55

FIG. 3

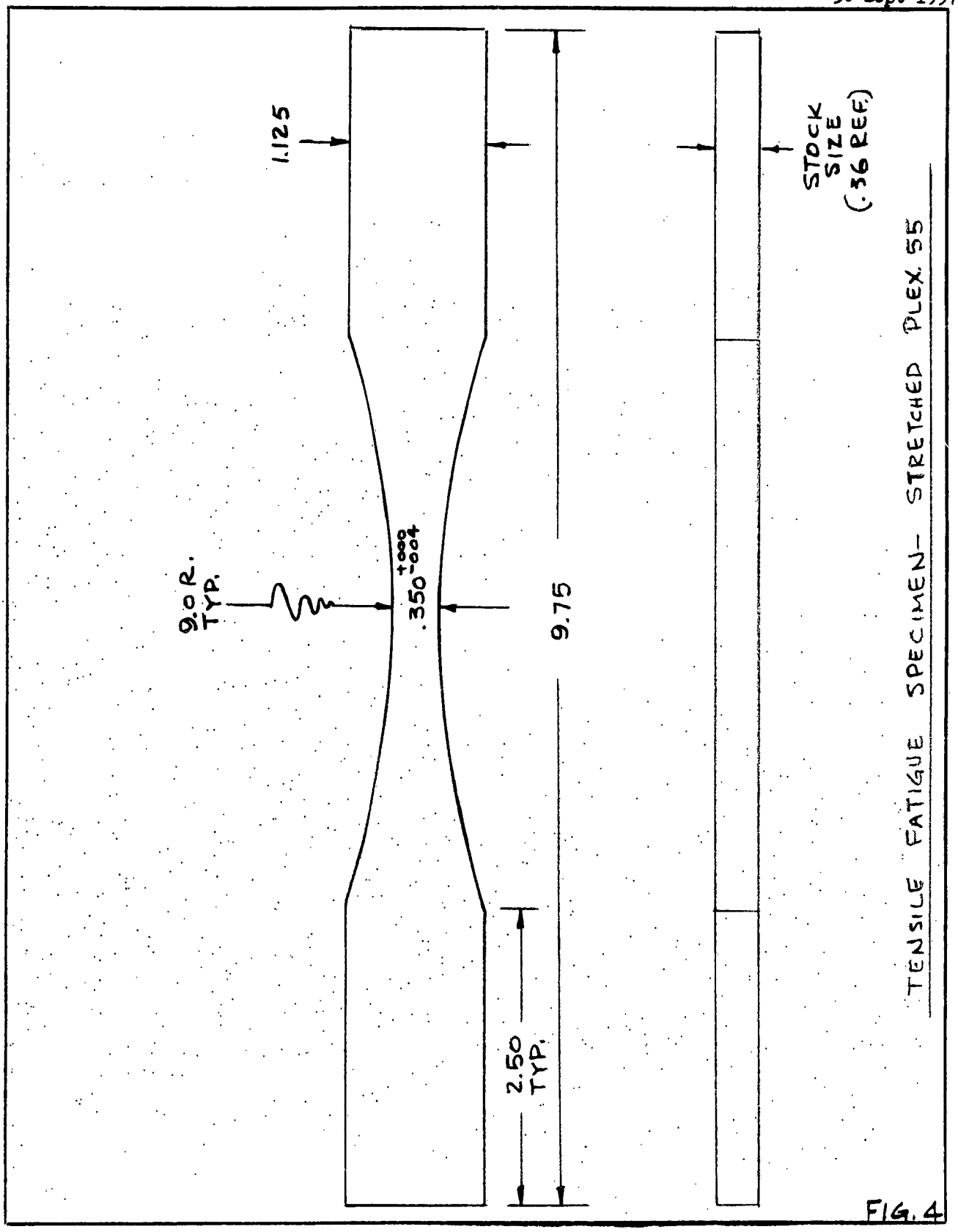
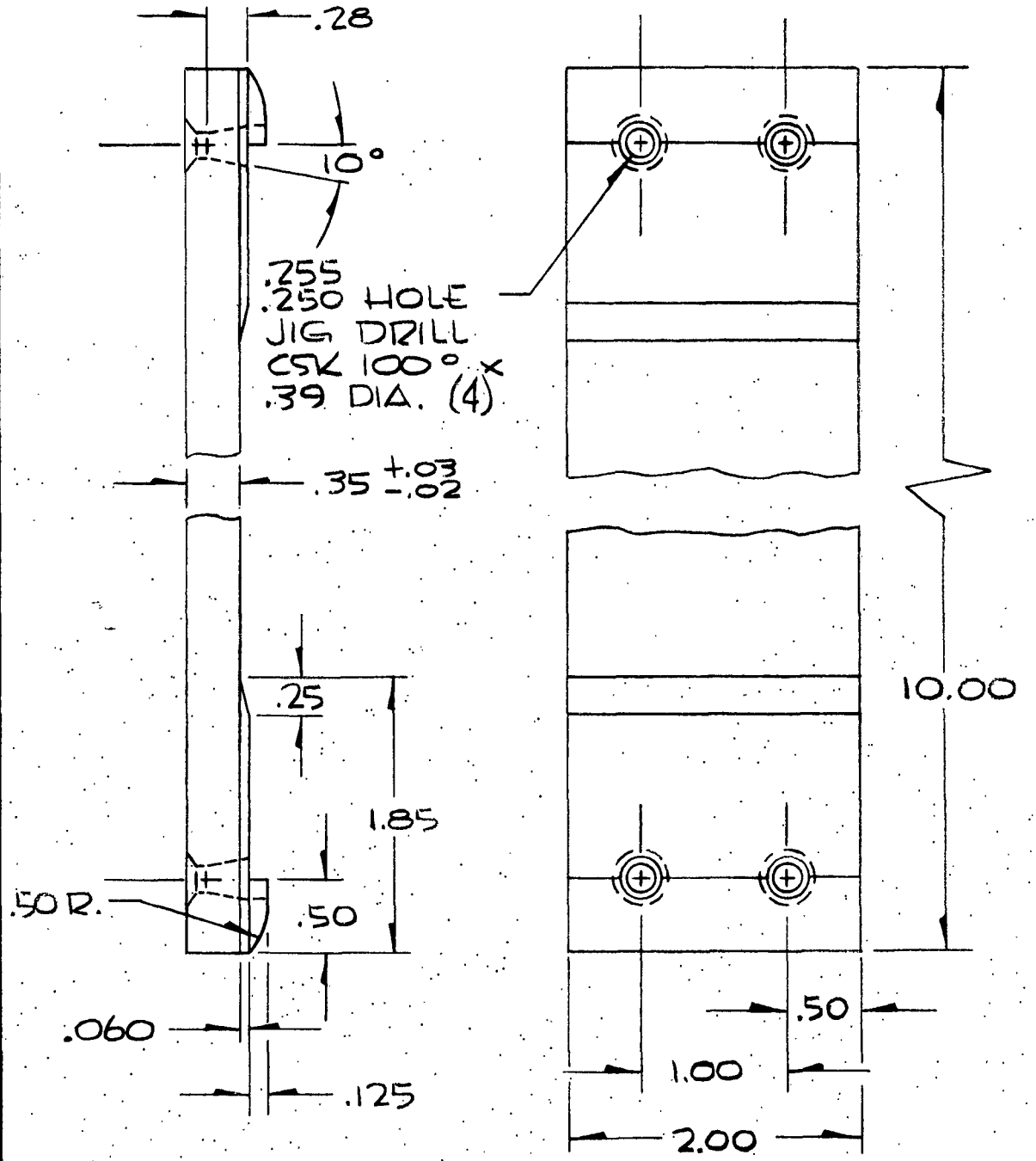
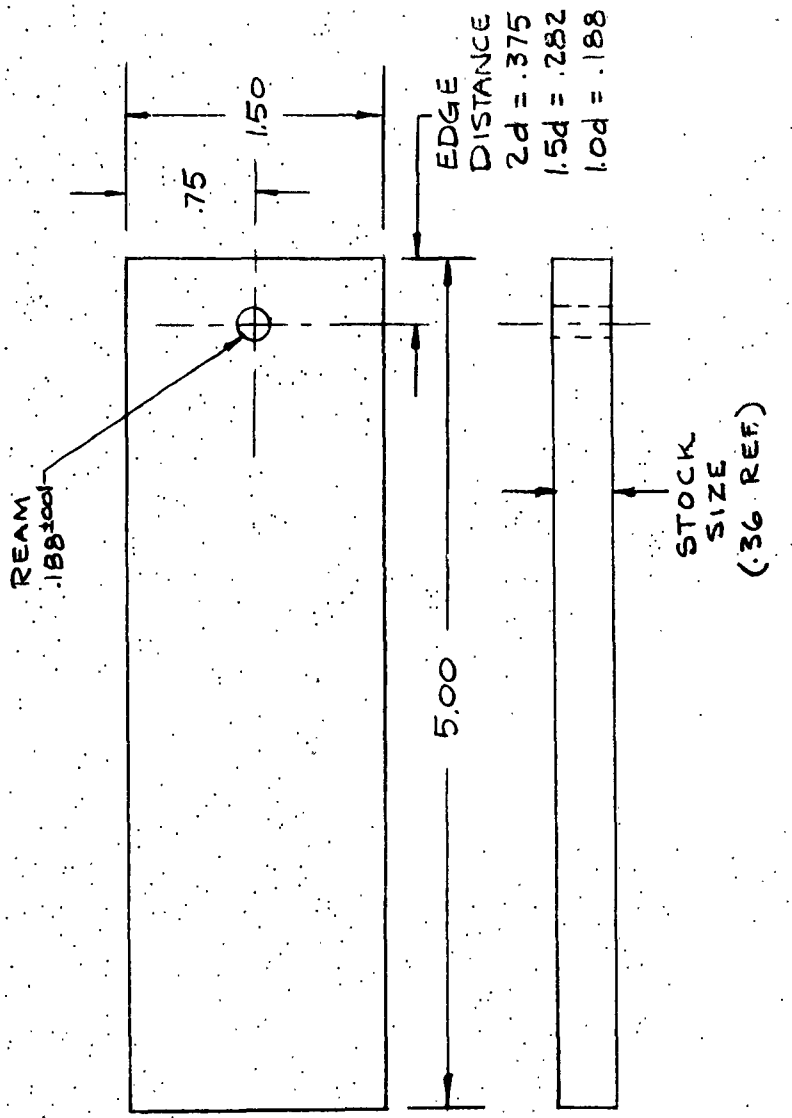

1.125
STOCK SIZE (.36 REF.)
9.0 R. TYP.
.350 +.000 -.004
9.75
2.50 TYP.
TENSILE FATIGUE SPECIMEN- STRETCHED PLEX. 55

FIG. 4



SPECIMEN - TEST,
EDGE ATTACHMENT, CANOPY WINDOW
8-07142

FIG. 5



SHEAR-OUT SPECIMEN - STRETCHED PLEXIGLAS 55

FIG. 6

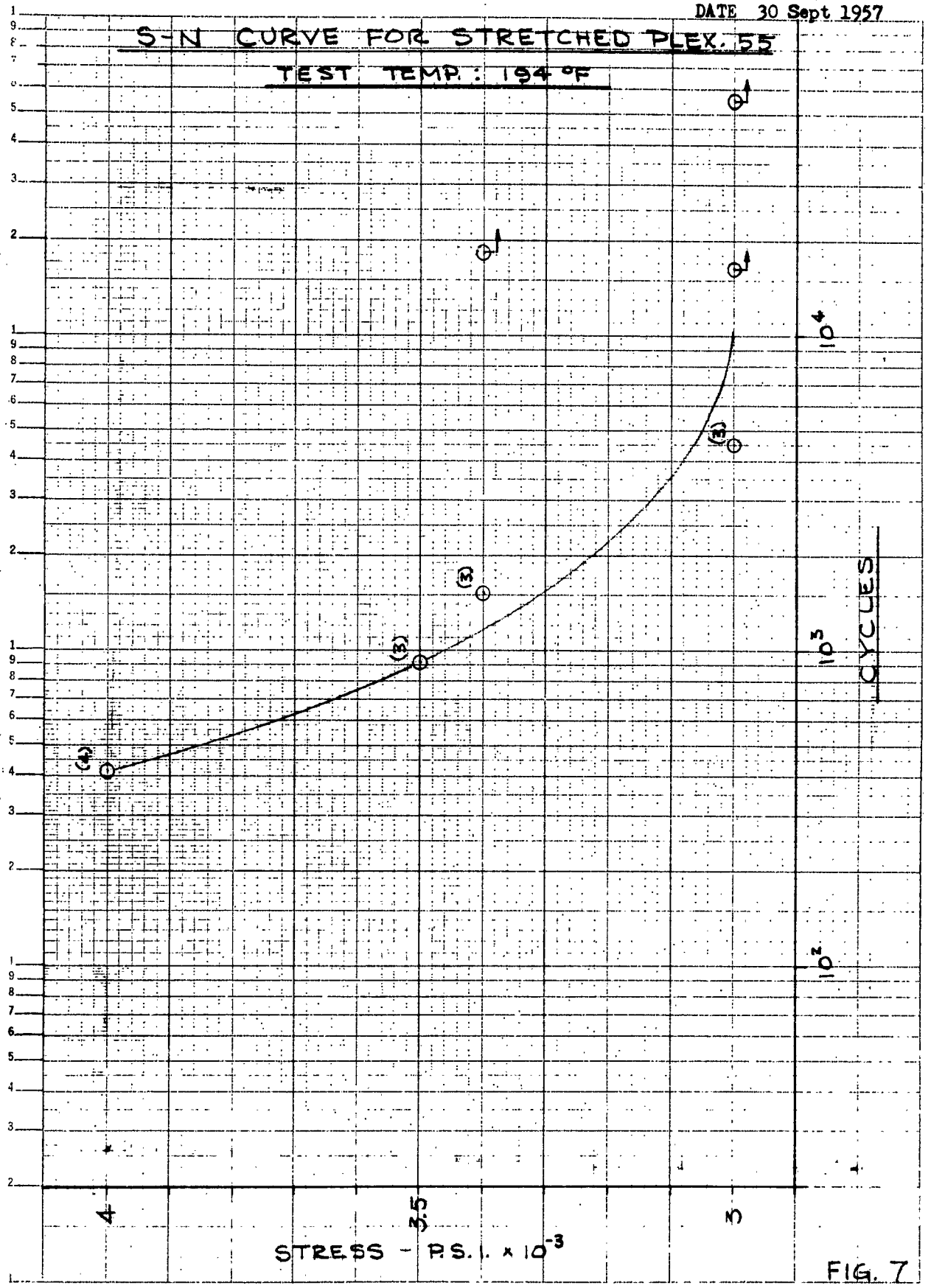

S-N CURVE FOR STRETCHED PLEX. 55
TEST TEMP. : 194 °F
(1)
(2)
(3)
(4)
10^4
10^3
10^2
CYCLES
4
3.5
3
STRESS - P.S.I. x 10^{-3}

FIG. 7

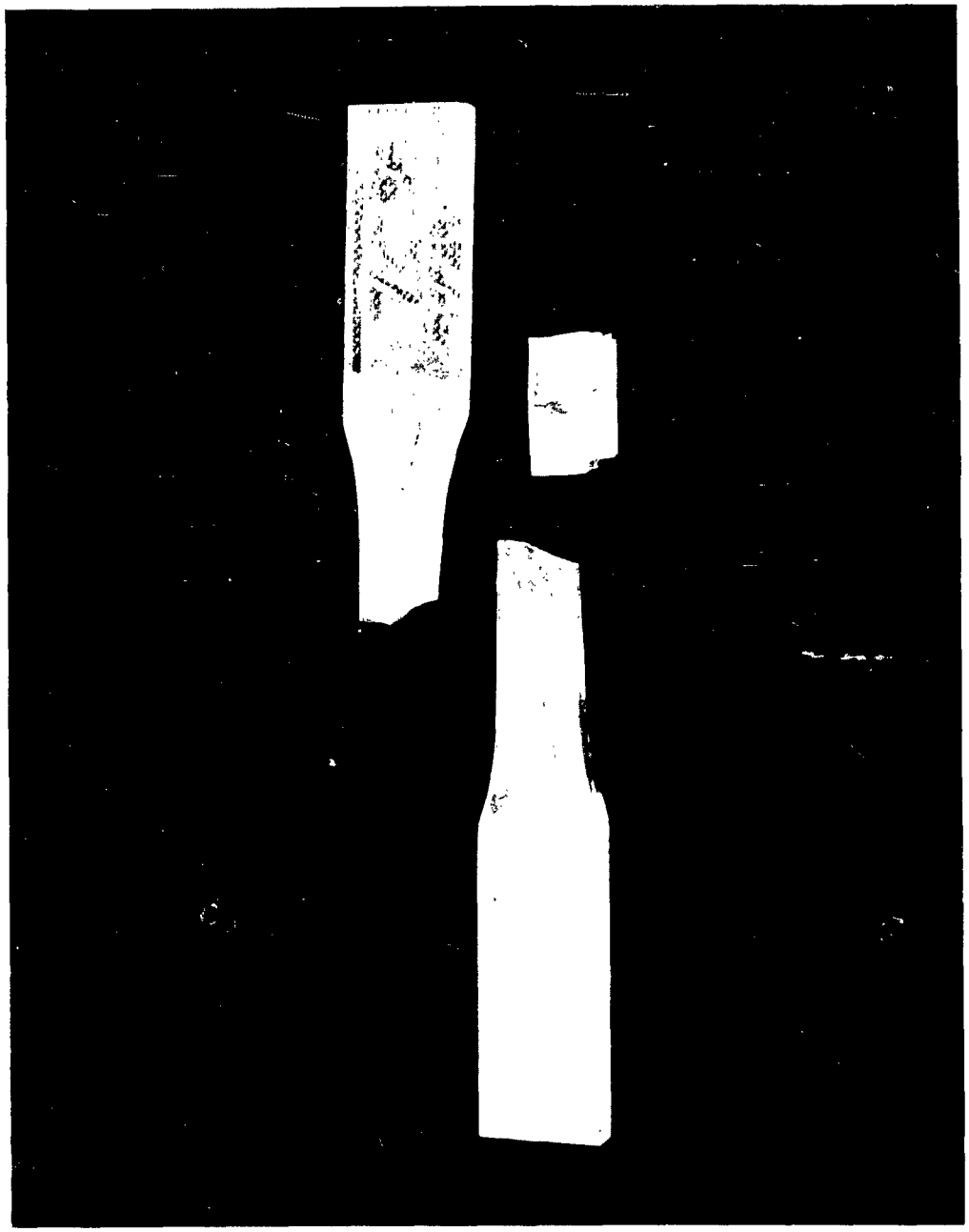


Figure 8 STATIC TENSILE FAILURE 75°F

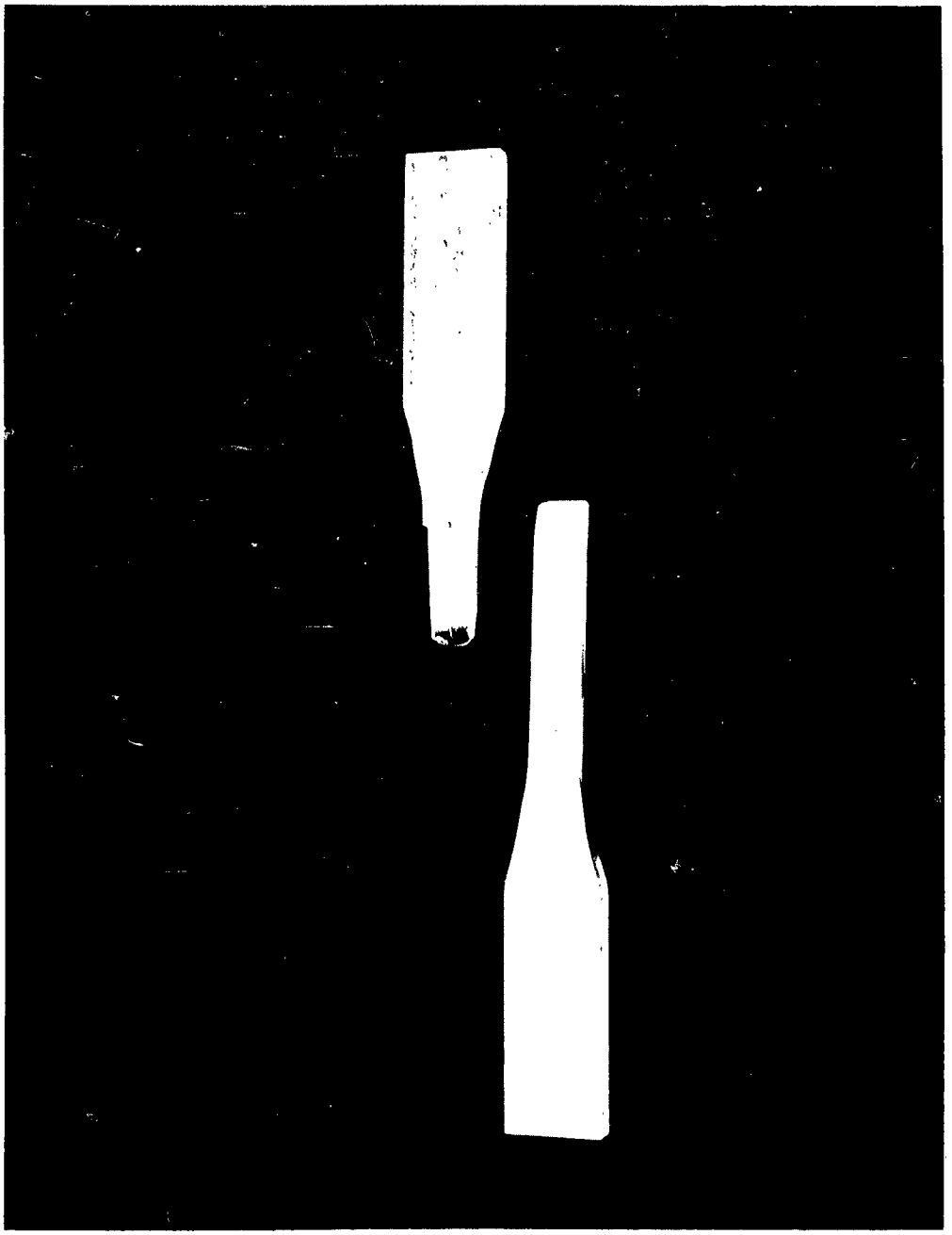


Figure 9 STATIC TENSILE FAILURE 194°F

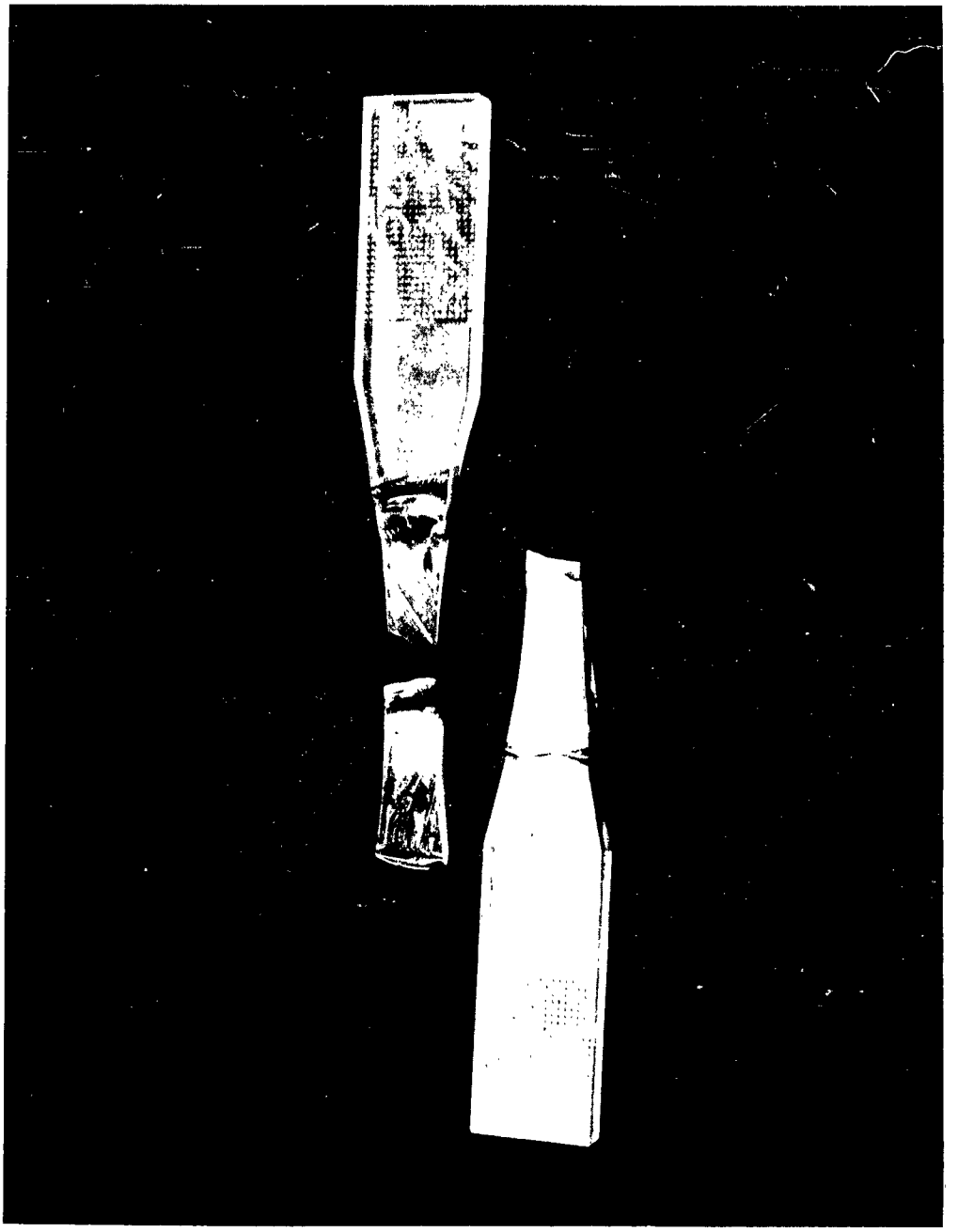


Figure 10 STATIC TENSILE FAILURE -50°F

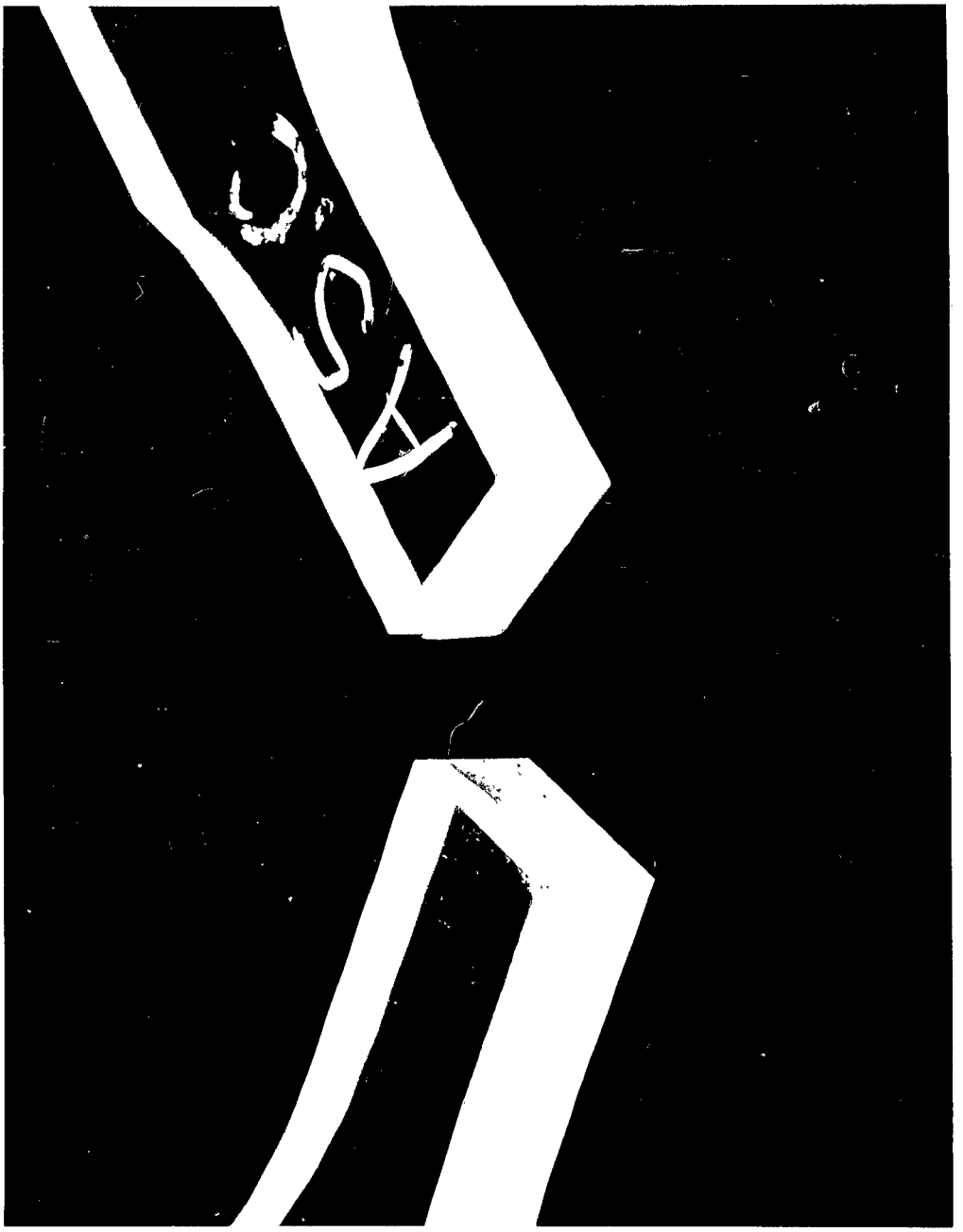


Figure 11 STATIC NOTCHED TENSILE FAILURE - AS-CAST PLEXIGLAS 55

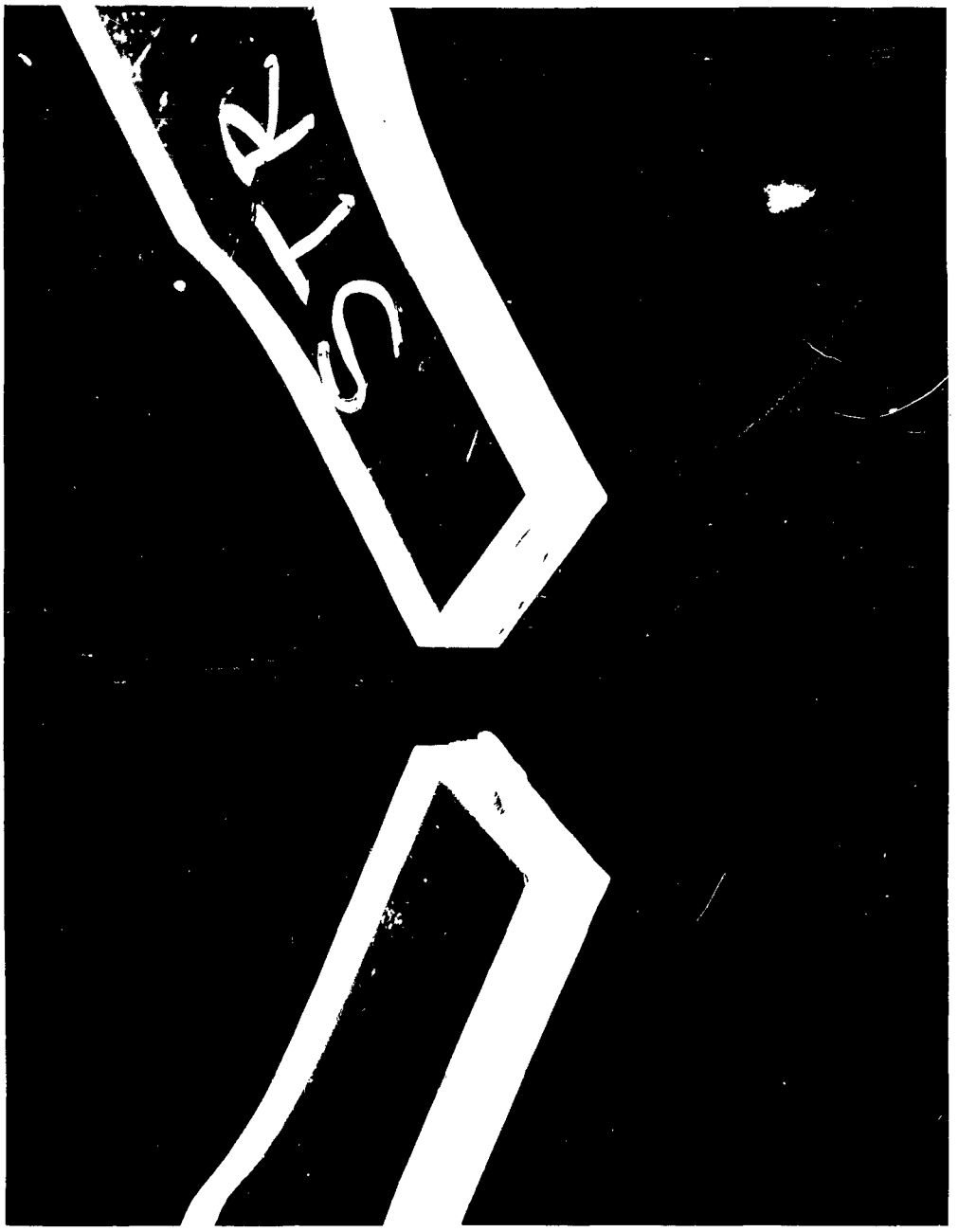


Figure 12 STATIC NOTCHED TENSILE FAILURE - STRETCHED PLEXIGLAS 55

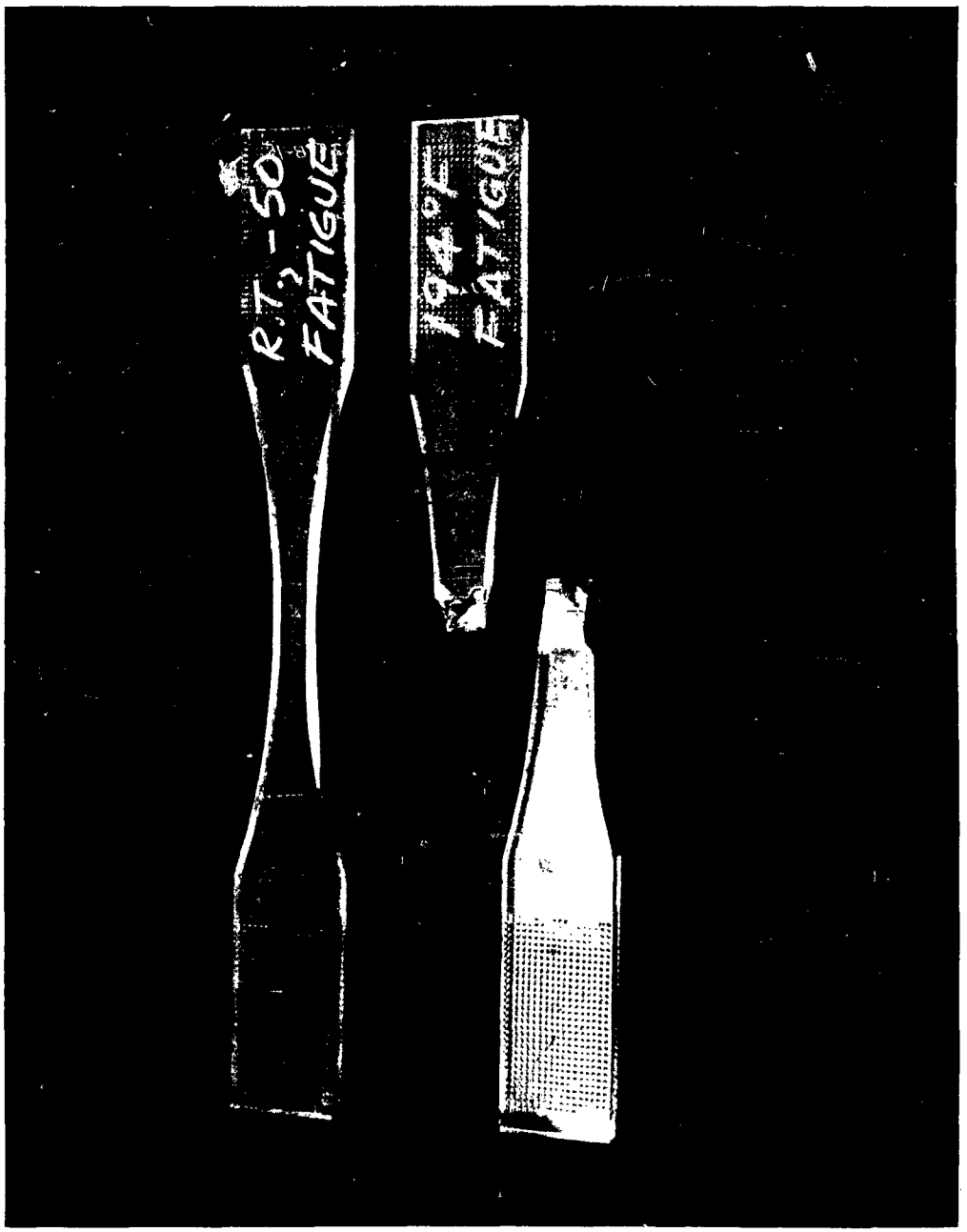


Figure 13 TENSILE FATIGUE SPECIMENS - STRETCHED PLEXIGLAS 55

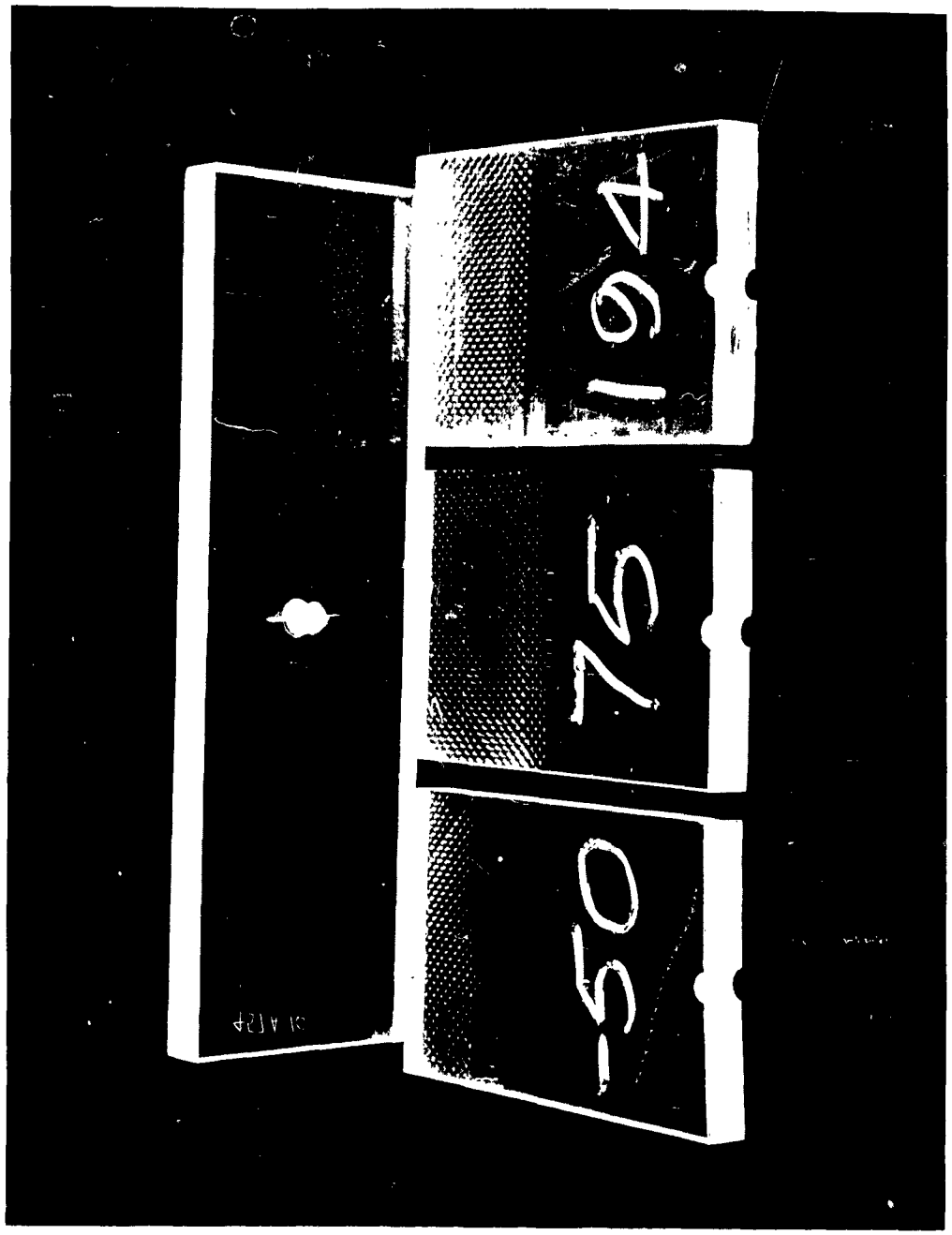


Figure 14 CRACK PROPAGATION SPECIMENS - STRETCHED PLEXIGLAS 55

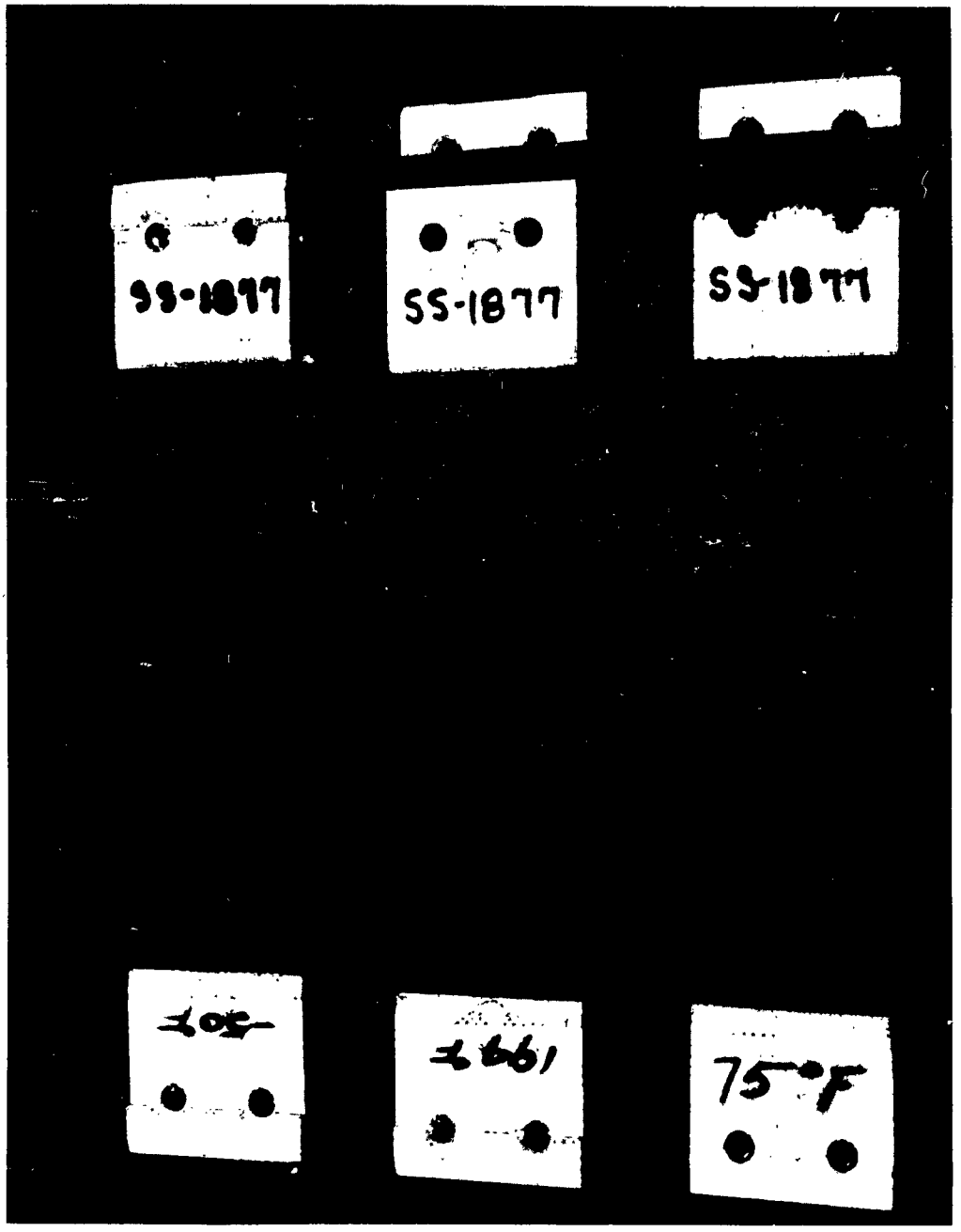


Figure 15 EDGE ATTACHMENT SPECIMENS - STRETCHED PLEXIGLAS 55

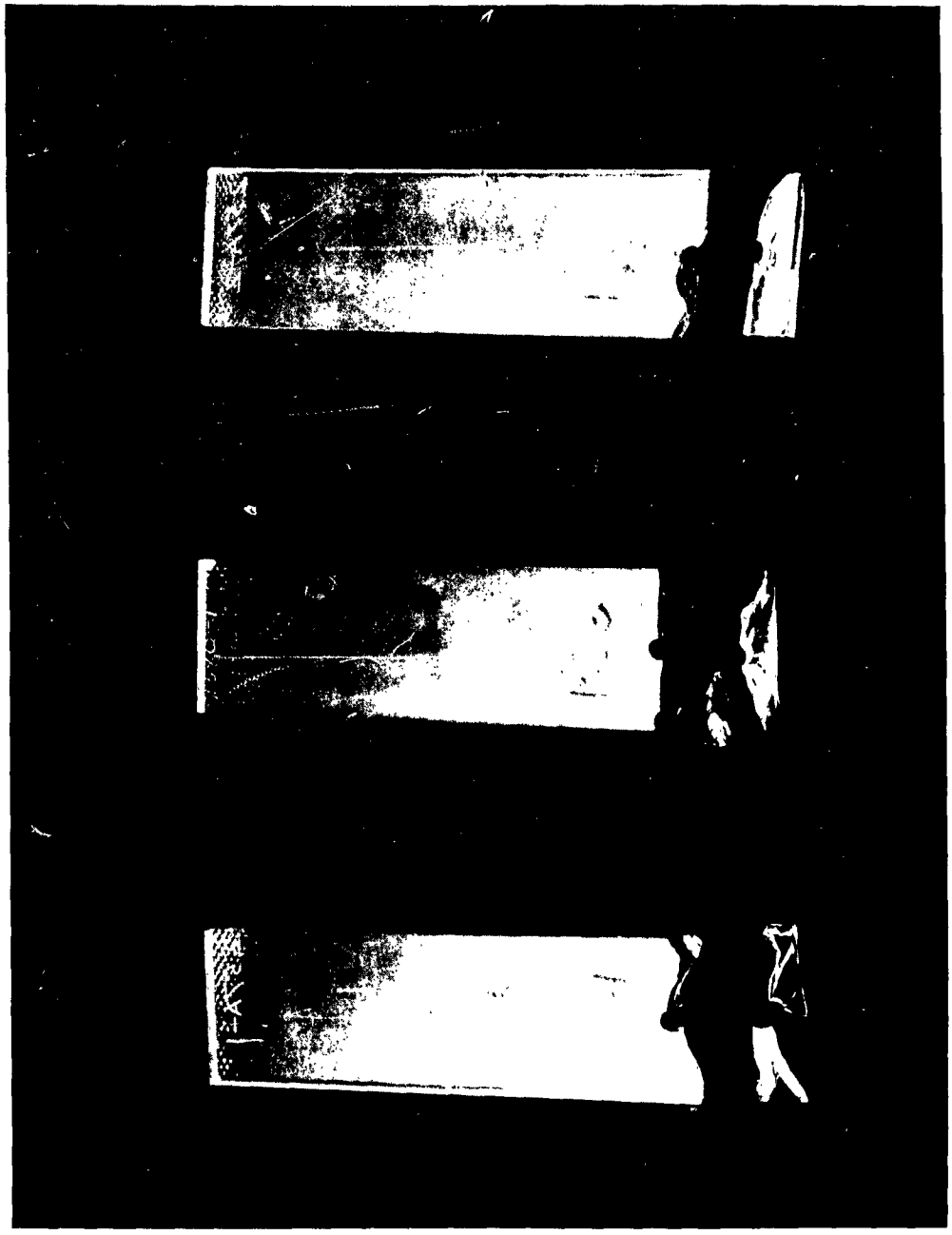


Figure 16 SHEAR-OUT SPECIMENS - STRETCHED PLEXIGLAS 55